Aquarius Overview and Up Date

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Abstract

Aquarius is an L-band instrument designed to map the surface salinity field of the global oceans. It consists of three L-band (1.41 GHz) radiometers and an L-band (1.26 GHz) scatterometer. The radiometers are the primary instruments for measuring salinity and the scatterometer provides a correction for surface roughness. Aquarius was launched in June 2011 and has been mapping the surface salinity field since it was turned on in August. In addition, Aquarius is now producing maps of radio frequency interference (RFI), Faraday rotation and soil moisture.

1. Introduction

The goal of Aquarius is to map the surface salinity field of the open ocean each month with a spatial resolution of 150 km and an accuracy of 0.2 psu [1, 2]. This is a challenging goal and, to meet it, Aquarius has a number of special features [1]. These include the addition of a scatterometer to help correct for the effect of surface roughness on emissivity; A polarimetric channel to measure the third Stokes parameter to help with the correction for Faraday rotation; Rapid sampling to help mitigate the effects of man-made radio frequency interference; Orientation and antenna design to help protect against contamination by L-band radiation from the Sun; And strict thermal control to maintain stability of the radiometer front ends.

Figure 1 is a drawing showing the observatory in its deployed configuration. It consists of three radiometers oriented in pushbroom fashion that look across track almost perpendicular to the direction of motion. The observatory flies out of the paper toward the reader with the long axis of the bus aligned perpendicular to the velocity vector. The three feeds and reflector can be seen in the figure. The reflector is a large parabolic dish 2.5 m in diameter. It produces radiometer antenna beams pointing across track (in the plane of the figure) which are about 7 deg wide (full width) at the 3dB point. The large umbrella-like structure to the right, and separating Aquarius from the SAC-D observatory bus, is a Sun shade which is part of the thermal design. The thermal design also includes active control of the radiometer front ends which maintains the thermal variations to less than 0.1 C around the orbit. Aquarius has only one scatterometer which cycles among the three feed horns [1]. The radiometers and scatterometer are designed to have approximately the same 3 dB footprint and measure at almost the same instant (once each 10 ms). See [1] for a timing diagram. The three radiometers together cover a swath of about 300 km, and map the globe once every 7 days.

2. Aquarius

Aquarius was launched in June, 2011 from Vandenberg Air Force Base, California, USA. The Aquarius/SAC-D observatory is a partnership between NASA and the Argentine space agency, CONAE. NASA provided the Aquarius instrument and CONAE provided the spacecraft bus (SAC-D) and several instruments [1]. The SAC-D is the structure in Figure 1 between the Aquarius sunshield and the solar panels. Among the instruments on SAC-D is a microwave radiometer (MWR) at 23.8 and 36.5 GHz which provides an estimate of rain. It is designed to have the same footprint as Aquarius and provide a real-time rain product to be included in the Aquarius processing. Research to incorporate this product is well underway but not yet compete.

Aquarius was turned on in August 2011 and the first salinity map was produced in September of the same year [3]. Observatory commissioning was completed in November and an official sea surface salinity product was released to the public about one year later. The data is available at the Physical Oceanography DAAC: http://podaac.jpl.nasa.gov/aquarius. Aquarius has been producing maps of the global sea surface salinity field continuously since it was turned on and has been performing well. The design and special features of the instrument are contributing to a successful mapping of surface salinity. Examples of the data being produced by Aquarius are presented below.

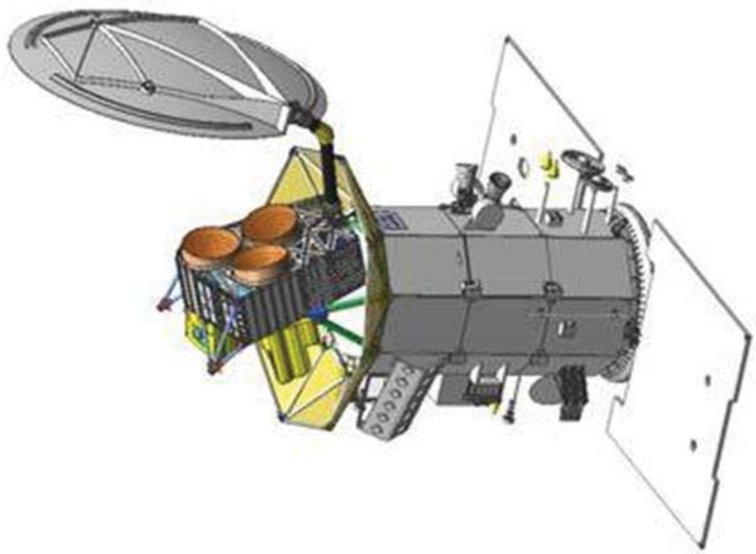

Fig 1: The Aquarius/SAC-D observatory. Aquarius is on the left separated from SAC-B by the sunshield.

3. Examples

3.1. Sea Surface Salinity

Figure 2 shows the global surface salinity field averaged for one year from September 2011 through August 2012. The map is constructed by re-gridding the Level 2 data to a resolution of 1-degree in latitude and longitude. The map reveals expected features of the ocean surface salinity field, such as higher salinity in the subtropics, higher average salinity in the Atlantic Ocean compared to the Pacific and Indian Oceans, and lower salinity in rainy belts near the equator and in the northernmost Pacific Ocean (Intertropical Convergence Zone, ITCZ). These features are related to large-scale patterns of rainfall and evaporation over the ocean and to river outflow and ocean circulation. Other important regional features are evident, including a sharp contrast between the high-salinity Arabian Sea west of the Indian subcontinent, and the low-salinity Bay of Bengal to the east which is dominated by the Ganges River and south Asia monsoon rains. Data from Aquarius allows researchers to monitor how features such as these change over time and study their link to climate and weather variations. An animation [3] made using Aquarius maps illustrates the dynamic nature of these features.

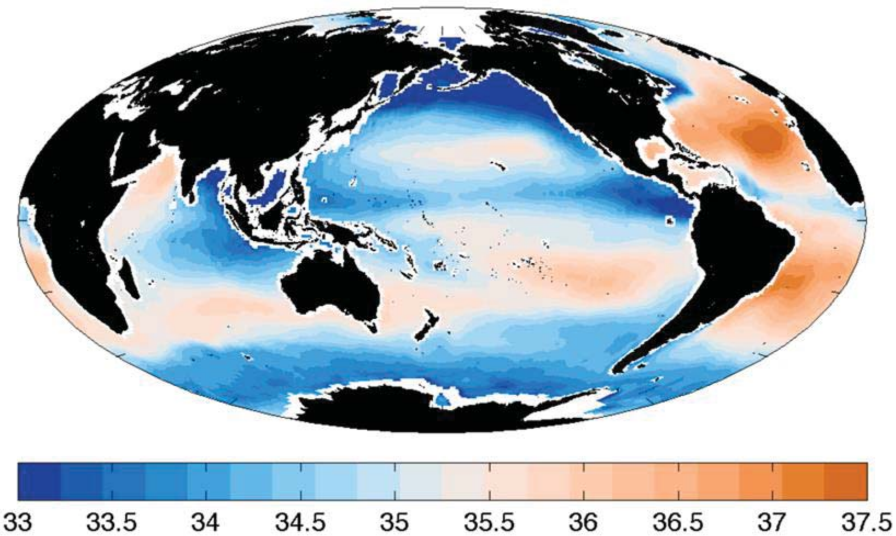

Fig 2: Average salinity field for one year: September 2011 to August 2012.

3.2. Radio Frequency Interference

One of the unique features of Aquarius is rapid sampling to help mitigate the effects of RFI. This has been working well [4] and although RFI over the open ocean is not nearly as severe as over land, interference from strong sources on land enters via the antenna sidelobes and if not detected and removed would severely compromise Aquarius' ability to retrieve salinity in areas of the North Atlantic and western Pacific Oceans. This is illustrated in Figure 3 which shows the percent of samples identified as RFI averaged for one year. The halos around North America and off the coast of Asia are indications of RFI from sources on land that have impacted Aquarius' radiometers via the antenna sidelobes. The large areas of land with very frequent RFI [red] indicates the problem SMOS and SMAP face in dealing with RFI over land.

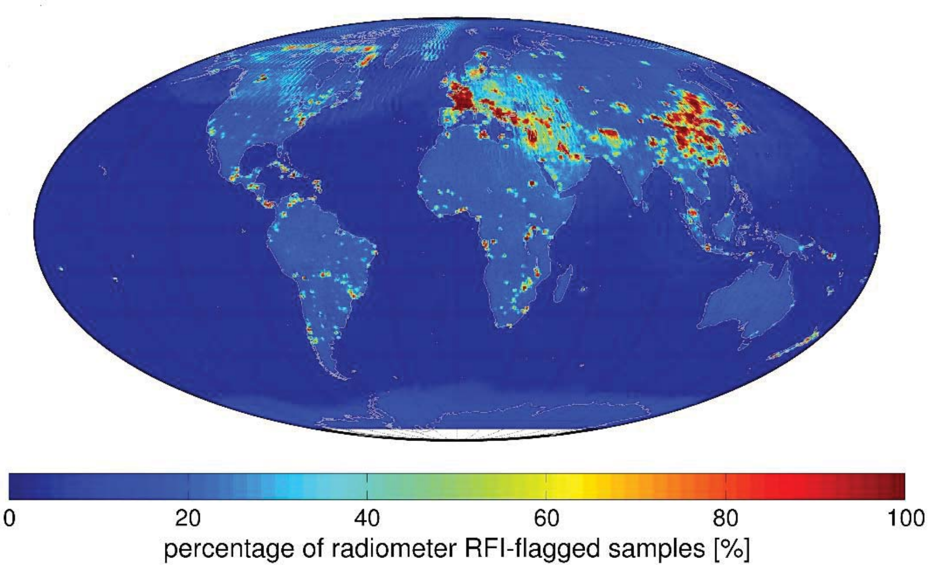

Fig 3: Map of radiometer RFI. Percentage of samples flagged as RFI for September 2011 to August 2012.

3.3. Faraday Rotation

The Aquarius radiometers measure the real part of the correlation of the signals at vertical and horizontal polarization (third Stokes parameter) in order to provide a real-time in situ measure of the Faraday rotation. The approach is based on the analysis of S. Yueh [5] and has been working well. As check on the retrieved Faraday rotation angles, a comparison was made with computations using the total electron content (TEC) from the IGS predictions and from the TEC measured by the Jason altimeter at intersections with the Aquarius orbits [6]. The agreement reported in [6] has been further improved since then as part of a fine tuning of the computation of the third Stokes parameter in the Aquarius retrieval (an adjustment of the antenna pattern correction matrix).

4. Conclusion

Aquarius is doing well and improvements are continuing to be made in the salinity product. Version 3.0 of the salinity product is expected to be released in March, 2014. It will include improved corrections for the effect of the celestial background signal reflected from the surface and an improved correction for roughness and estimated winds. In addition, new applications continue to emerge. For example, a soil moisture product is now available at the National Snow and Ice Data Center (NSIDC) [7] and new application are being developed for the study of the cryosphere [8, 9].

5. References

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